

A lighthouse costs less than shipwrecks.



Prevention costs less than disease.

The National Insulin Resistance Council

A not-for-profit disease prevention organization

Metabolism's Biochemical Symphony: Glucose and Insulin

A healthy person has only trace levels of both glucose and insulin in the bloodstream most of the time. Food you eat triggers digestion in your stomach, which continues in your small intestine. Digestion breaks down complex chemicals in food into simpler ones. Glucose, chemically a simple sugar, is the body's energy fuel. Glucose is to your body's muscle cells what gasoline, refined from complex petroleum, is to a car's engine.

Within a half-hour after eating, your blood glucose level starts to rise. That increase triggers insulin production by your pancreas' beta cells and insulin flows directly into the blood as a result. In a normal person, by about three hours after eating, both glucose and insulin levels will have returned to trace, or near-zero levels. During that time, glucose was either absorbed by individual muscle cells throughout the body where it was used as fuel, or it was captured by the liver which converted it into glycogen, the form in which the body stores energy for future use. With glucose absent, no-longer-needed insulin is filtered from the blood by the kidneys and expelled in urine. Until the next meal, blood glucose and insulin levels remain at trace levels. If you have a sudden need for energy, the liver reconverts glycogen it has stored back into glucose and insulin is produced as if the glucose had arrived for the first time.

The word insulin is from the Latin word for islands, *insulae*. It refers to the physical arrangement of the beta cells within the pancreas. In chemical terms, insulin is a protein. Biologically and medically, it is a hormone, since the body creates it and delivers it directly into the blood. Insulin is among the smallest and most ubiquitous proteins in nature. So fundamental to life, with small variations, insulin is the same in a worm as in a human. In fact, it was insulin taken from cows that was first used to save the lives of humans with type 1 diabetes, those who cannot create their own insulin.

Insulin is the essential enabler when it comes to energy. The standard metaphor is that an insulin molecule acts like a key in a lock. Glucose is the simple sugar and body's fuel, and muscle cells are the engines. But glucose absorption by a muscle cell is only possible when an insulin molecule is temporarily attached to a specialized receptor on its outer wall. Once glucose is absorbed, the cell jettisons the insulin molecule which continues to float in the blood. Once nearly all the glucose floating around has been absorbed, the body gets rid of the insulin.

If that were not enough, insulin directly influences the body's energy handling in a second crucial way. Insulin present in the blood is the liver's signal to grab and convert glucose into glycogen, the body's nearly instant energy supply in stored form. Even when the liver has stored all the glycogen it can physically hold within it, about a pound, as long as insulin is in the blood, it continues to convert glucose to glycogen, but releases it into the bloodstream. Adipose cells absorb the glycogen and store it as long-term energy reserves. Adipose tissue stuffed with glycogen is what we know as body fat. Human metabolism is based on our ancestral

biology of the hunter/gatherer's uncertainty of when the next meal will occur, rather than on a schedule of two or three squares a day, an extremely modern phenomenon in evolutionary terms. There is a strong biological bias to storing energy for future needs, even among people with normal metabolisms. This alone accounts for the relative ease people have of gaining weight, and the relative difficulty of losing it.

When insulin is at near-zero levels, and energy is demanded by muscle cells, the liver first reconverts its own stored supply of glycogen and then any released by adipose cells back into glucose. Insulin at near-zero levels is also the signal for adipose tissue to release glycogen so the liver can convert it back to glucose.

In one of nature's unbelievably complex biochemical symphonies performed multiple times a day, glucose enters the blood, insulin is created, energy is absorbed and stored, and excess insulin is flushed out. Between meals, energy is recouped from stored form causing glucose and insulin levels to rise and fall as needed. Please be aware that there are other hormones and chemicals involved in these signaling and conversion processes, but discussing them here obscures the central role of insulin.

Someone with *insulin resistance* creates too much insulin. The condition, known as the medical mouthful *hyperinsulinemia*, actually refers to two kinds of excess: more insulin than what a normal metabolism needs for a given amount of glucose, and insulin above trace levels more of the time. It is these two insulin excesses that are tied into much of our non-infectious diseases and other less serious symptoms.

Research has shown that insulin, as a chemical, eats away the inner linings of blood vessels and certain nerve tissue sheathing over time as it floats in the bloodstream. The more of it there is, and the longer it is present, the more the body endures insulin's corrosive effects instead of just its life-giving properties. These effects accumulate over years, and are direct contributors to the most serious outcomes later on including heart disease and the kidney failure, blindness and amputations that accompany diabetes.

Excess insulin also irritates, or over-stimulates other hormone producing organs. Women with *PCOS* are an important example. The pituitary gland generates excess LH, and the ovaries generate excess testosterone. Each of those causes its own unwanted effects, including reproduction problems. [Learn more about **Metabolic Syndrome and PCOS** [here](#)].

Lastly, as long as insulin is present, the body strives to make more fat, and refuses to generate energy from short or long term stores. That's why pronounced fatigue is a common symptom of *metabolic syndrome*, *PCOS* and of *diabetes*, since energy is scarce even when stores of fuel are plentiful.

The goal of the National Insulin Resistance Council (NIRC) is to *prevent* millions of non-infectious disease cases tied to *insulin resistance* including diabetes, heart failure, stroke and recently-linked Alzheimer's. It sponsors, operates, and collaborates with others on programs that lead to *early identification* of affected individuals and fosters targeted *active prevention* programs.